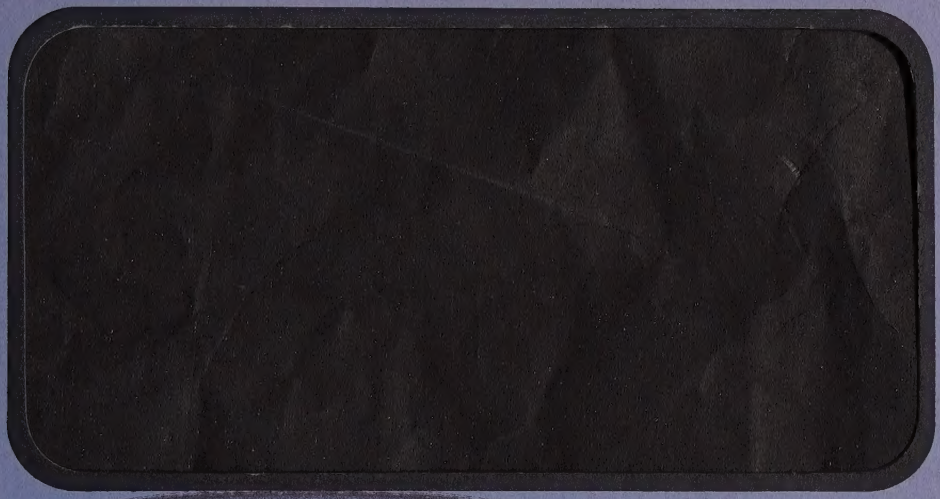

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OPERATING AND MAINTENANCE MANUAL

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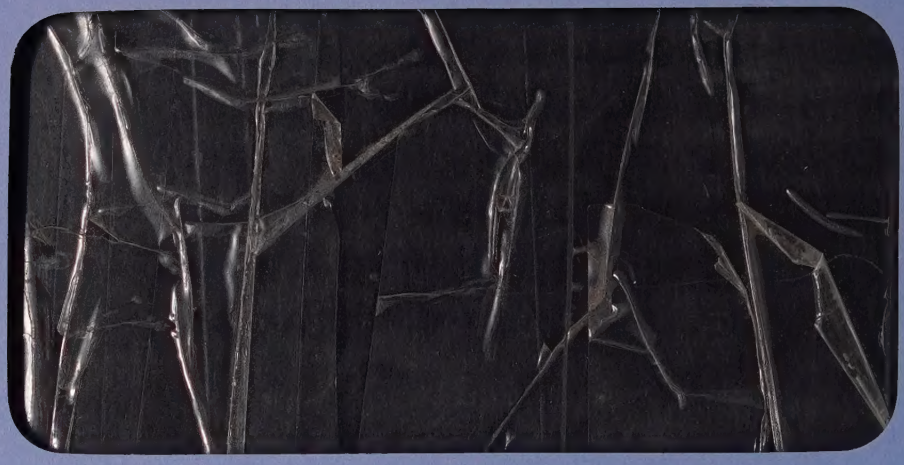

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Do not return the instrument without our written authorization for, in most cases, we will be able to supply you with the information necessary to repair the instrument and thus avoid the transportation problems and costs. When it becomes necessary to return the instrument to our Factory, kindly pack it carefully and ship it to us prepaid.

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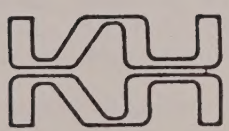
10Hz TO 5MHz

DIGITAL PHASEMETER

MODEL 6400 SERIAL NO. _____

OPERATING AND MAINTENANCE MANUAL



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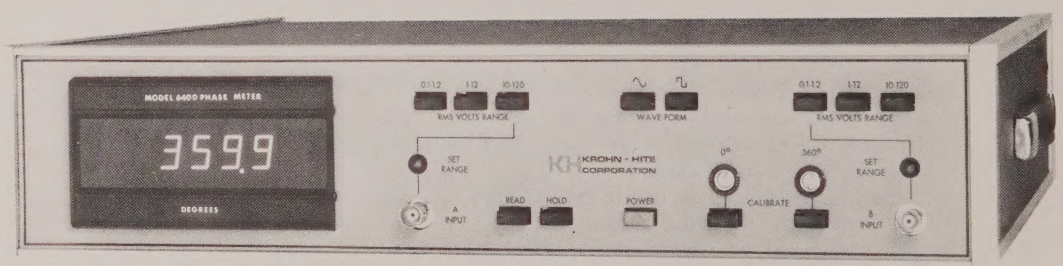


Figure 1. Model 6400 Phasemeter

SECTION 1
GENERAL DESCRIPTION

1.1 INTRODUCTION

The Krohn-Hite Model 6400 Phasemeter measures the phase angle between two waveforms of coincident frequency, over a range of 10 Hz to 5 MHz, and provides a basic accuracy of 0.1°, with 0.1° resolution. A 5 digit Beckman display provides direct readout of the phase angle from 000.0° to 360.0°. The 6400 accepts input voltages from 0.1 volts RMS to 120 volts RMS, and the phase accuracy is unaffected by differences in the input signal levels. The fluctuations or inconsistencies normally encountered in phase angle readings near zero and 360° (sometimes referred to as ambiguity) are eliminated by a unique network in the 6400 that permits readings near zero or 360.0 to be observed, without the need of changing ranges or 180° shifting. In addition, the circuitry of the 6400 significantly reduces the effects of distortion and noise on phase accuracy. An analog output on the rear panel provides a DC voltage equal to -10 mv/degree phase, for use with an external meter or recorder. A read/hold switch also provides continuous display of the phase angle reading, or holding of the reading for an indefinite period.

The phasemeter is carefully inspected, aged, and adjusted before shipment, and should be ready for operation when it is unpacked. If it appears to have been damaged in shipment, make a claim with the carrier, and notify Krohn-Hite immediately.

1.2 SPECIFICATIONS

Frequency Range

10 Hz to 5 MHz.

Accuracy

Sine Wave: ±0.1° ±1 digit from 10 Hz to 50 kHz, rising to ±0.7° at 100 kHz; ±0.2° at 10 Hz; ±0.7° per 100 kHz above 100 kHz; for any amplitude within selected range.

Square Wave: ±0.1°, ±1 digit from 10Hz to 20kHz, ±0.7° per 100kHz above 20kHz; for any amplitude within selected range.

(May be used for reference measurements to 5 MHz.)

Display

4 digit gas planar discharge, 000.0° to 360.0°.

Resolution

0.1°.

Drift (30 day period):

Sine Wave: ±0.1° from 10 Hz to 50 kHz; ±0.4° per 100 kHz above 50 kHz.

Square Wave: ±0.1° from 10 Hz to 20 kHz; ±0.4° per 100 kHz above 20 kHz.

Repeatability

Better than 0.1°.

Temperature Coefficient

±0.06°/°C 10 Hz to 100 kHz; above 100 kHz add ±0.05°/°C per MHz to 5 MHz.

Input Signal Amplitude

0.1 volts RMS to 120 volts RMS in three ranges 0.1-1.2, 1-12, 10-120 (can be extended with Tektronix type P6006, P6007, P6013A, P6049A or P6060 matched probes).

Input Impedance

1 Megohm in parallel with 50 pf.

Response Time

Within specified accuracy, within one to eight seconds dependent upon input signal amplitude.

Maximum DC Component

±200 volts (can be extended with Tektronix type P6006, P6007, P6013A, P6049A or P6060 matched probes).

Analog Output (for use with an external meter or recorder)

0 to -3.6 volts DC, -10 mv DC/degree phase, impedance 250 ohms.
Drift, ±0.1°/30 days.

Ambient Temperature Range

0°C to 45°C.

Panel Controls and Adjustments

3 decade attenuator push button switch (each channel), read-hold, waveform, power, 0 degree CAL and 360 degrees CAL.

Terminals

BNC, both input channels, front and rear panel; BNC for analog output, rear panel only.

Power Requirements

105-125 volts, or 210-250 volts, 50-60 Hz, 40 watts.

Dimensions and Weights

Bench Model 6400: 16 1/2" wide, 3 1/2" high, 16" deep, 15 lbs/6.8 Kgs net, 18 lbs/8 Kgs shipping.

Rack Model 6400R: 19" wide, 3 1/2" high, 16" deep, 15 lbs/6.8 Kgs net, 18 lbs/8 Kgs shipping.

1.3 FACTORS AFFECTING PHASEMETER ACCURACY

1.3.1 Inconsistencies in Meter Readings Near 0° and 360°

A problem affecting a phasemeter's accuracy is the inability of the phasemeter circuit to detect relatively small phase angles, resulting in meter fluctuations or inconsistencies in readings. The 6400 overcomes this inconsistency (or ambiguity as it is sometime referred to) by using a specially designed network that permits measurements near zero or 360.0 to be made without meter fluctuations or repeatability errors, and eliminates the need for multiple meter ranges, or shifting of the meter scale.

1.3.2 Distortion Present on the Input Signal

If there is distortion present on one of the signals, a phase error may be introduced, depending on the relationship between the fundamental and its harmonics. If the amplitudes of all odd or even harmonics add up to zero at the negative zero crossing of the fundamental, then the harmonics will produce no phase error. If the resultant of the amplitudes is not zero, however, it will cause a shift in the zero crossing of the input waveform. (Worst case would occur when the maximum of the harmonic coincides with the negative zero crossing of the fundamental.) The effect of an even harmonic will not only shift the zero crossing of the waveform, but also alter the symmetry of the comparator or detector output. If a symmetry control loop is added to the phasemeter circuit, the effect of the even harmonic on accuracy can be minimized. The 6400 uses the type of symmetry loop mentioned above.

The effect of an odd order harmonic, however, is not as easily corrected. The effect of an odd order harmonic out of phase with the fundamental simply shifts the phase of the output of the comparator or detector loop. Since the symmetry is not affected there is no way to detect any phase error.

Figure 2 shows the maximum phase error introduced versus the percentage of harmonic distortion present on each input channel.

1.3.3 Noise Present on the Input Signals

Another problem which will affect phase accuracy is random noise. If there is a sufficient noise level on either input (or both), false triggering will occur and a phase error is introduced. The 6400 uses special circuits plus filtering to minimize the effects of noise on the phase accuracy. Typically, any broadband noise present on both inputs 40 db down from the input signals will produce only a 0.05° error. Figure 3 gives a typical curve for phase error versus input frequency, for a signal to noise ratio of 10:1 on both inputs.

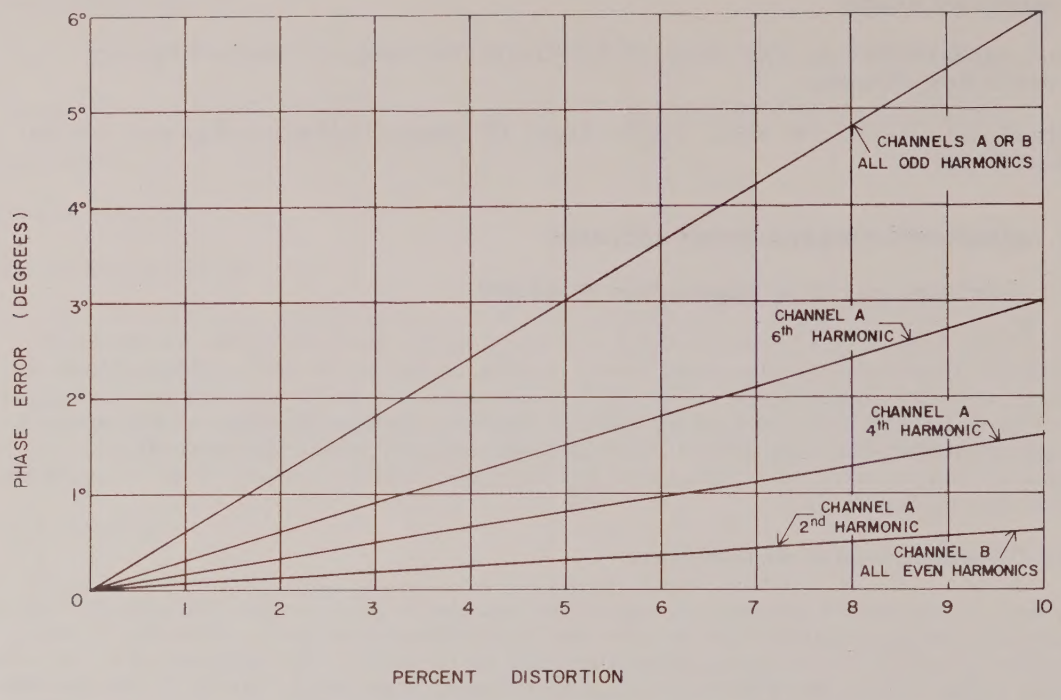


Figure 2. Maximum Phase Error* vs % Harmonic Distortion

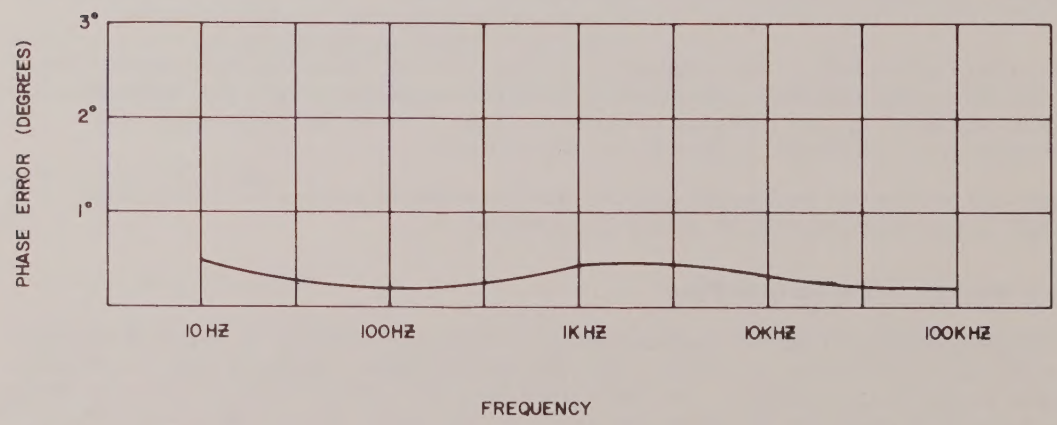


Figure 3. Phase Error vs. Gaussian Noise

*(Worst case would occur when the maximum of the harmonic coincides with the negative zero crossing of the fundamental.)

SECTION 2

OPERATION

2.1 POWER REQUIREMENTS

The Model 6400 Phasemeter may be used with either a 105 - 125 volt, 50 - 60 Hz line or a 210-250 volt 50 - 60 Hz line. The line voltage can be selected by operation of the LINE switch on the rear panel. When the line voltage is 115 volts, a 0.5 ampere fuse is required; when the line voltage is 220 volts, a 0.25 ampere fuse should be used.

2.2 OPERATING CONTROLS, DISPLAYS AND CONNECTORS (See figure 4)

2.2.1 Front Panel Controls

POWER: On-off pushbutton switch.

WAVEFORM: Two-position push button switch selects sine wave or square wave mode of operation. When sine or triangle waveforms are used as input signals, the WAVEFORM switch should be set for ⌒; when square waves or positive pulses are used, the WAVEFORM switch is set to the ⊓ mode.*

RMS VOLTS RANGE: Three position push button switch (each channel) for selecting input voltage ranges from 0.1 volts RMS to 120 volts RMS. The voltage ranges are 0.1-1.2, 1-12 and 10-120. The voltage range may be extended using Tektronix matched probes. (Types P6006, P6007, P6013A, P6049A, or P6060).

READ/HOLD: Two - position push button switch. In the READ mode, the phase angle being measured is continuously displayed on the readout. In the HOLD mode, the last reading is held for an indefinite period.

0° CAL: Push-button hold-release switch for checking 0° calibration. A front panel screwdriver control is also provided for adjustment of zero scale.

360° CAL: Push-button hold-release switch for checking 360° (full scale) calibration. A front panel screwdriver control is also provided for adjustment of full scale.

2.2.2 Rear Panel Controls

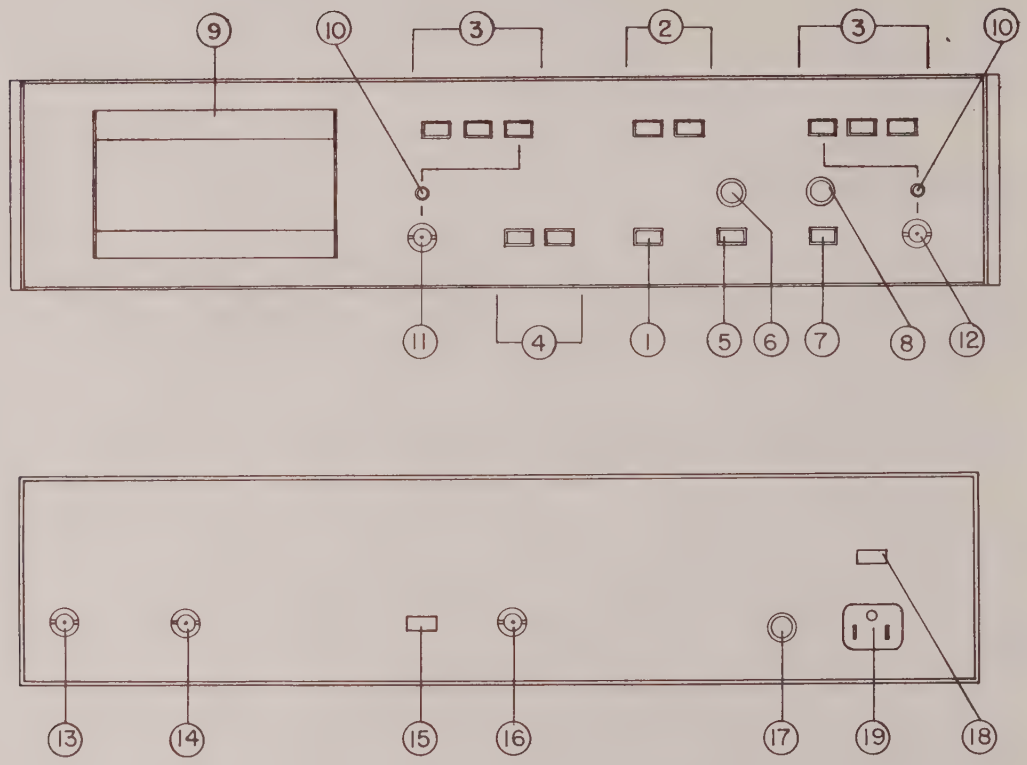
LINE: Two-position slide switch for selecting 115 or 230 volt operation.

CHASSIS/FLOATING: Two-position slide switch for selecting chassis or floating ground. In the FLOATING mode, signal ground is isolated from chassis ground.

2.2.3 Displays

4 digit gas planar discharge displays the phase angle being measured, in degrees, from 000.0° to 360.0°.

*(The phasemeter is triggered on the negative going transition of the input waveform, in both sine and square wave positions of the WAVEFORM switch.)



1. POWER SWITCH
2. WAVEFORM SWITCHES
3. RMS VOLTS RANGE SWITCHES
4. READ/HOLD SWITCHES
5. 0° CAL SWITCH
6. 0° CAL SCREWDRIVER ADJUST
7. 360° CAL SWITCH
8. 360° CAL SCREWDRIVER ADJUST
9. DIGITAL PANEL METER
10. SET RANGE INDICATORS
11. CHANNEL 'A INPUT (BNC)
12. CHANNEL B INPUT (BNC)
13. CHANNEL B REAR INPUT (BNC)
14. ANALOG DC OUTPUT
15. GROUND SWITCH (CHASSIS/FLOATING)
16. CHANNEL A REAR INPUT (BNC)
17. FUSE
18. LINE SWITCH
19. POWER RECEPTACLE

Figure 4. Operating Controls, Displays and Connectors

SET RANGE: Front panel LED indicator, (one for each channel) illuminates when the input voltage for that particular channel is either above or below the selected range.

2.2.4 Connectors

Front panel: BNC connector for each channel input.

Rear panel: BNC connector for each channel input. ANALOG OUTPUT, BNC, equal to -10 mv/degree phase, for use with external meter or recorder. Power Receptacle for line cord.

2.3 OPERATION

To operate the 6400 phasemeter proceed as follows:

1. Make appropriate power connections (see Section 2. 1).

2. Push the POWER switch to the ON (recessed) position, and allow the unit to warm up for at least 30 minutes to achieve rated accuracy.

3. Set the READ/HOLD switch to the READ position.

4. Push the 0° CAL button. Adjust the 0° screwdriver control (if necessary) so that the meter reads 000.0°.

5. Push the 360° CAL button. Adjust the 360° screwdriver control (if necessary) so that the meter reads 360.0°.

After the unit has been allowed to warm up, connect the reference signal to the A input and the signal to be measured to the B input.

(It is recommended that matched, equal length, coaxial input cables be used, as a difference in length or cable capacitance may affect the phasemeter accuracy, particularly at high frequencies. As an example, consider two cables that are the same type (approximately 30 pf/foot) but of different length. A difference of one foot between the two cables will create an error at 100 KHz of about 0.06°.)

After connecting the cables to the two input channels, set the WAVEFORM switch to the desired mode. In the ∿ mode, the phasemeter will measure phase angles between sine waves, a sine and triangle wave, or triangular waves. In the ⊓⊔ mode, square waves, a square wave and positive pulse, or positive pulses should be used. If a sine wave is used in the ⊓⊔ mode or vice-versa, an error of several degrees can be expected.

After selecting the proper WAVEFORM mode, set the VOLTS RMS RANGE buttons to a position where the LED indicator is extinguished. This will indicate that the input signal level is within the proper range. The 6400 will now display the phase angle, in degrees, between the two input signals. Refer to Section I for the appropriate accuracy specifications.

If the phase angle reading is near $0^{\circ}(\pm 5^{\circ})$ or $360^{\circ}(\pm 5^{\circ})$, it is possible to shift the phase reading as follows:

If the meter is reading near 0°, and a reading near 360° is desired, simply depress the 360° CAL button for about 3 seconds, then release. If the meter reading is near 360°, and a reading near 0° is desired, simply depress the 0° CAL button for about 3 seconds, and then release.

When the input voltage level exceeds 120 volts RMS, or the DC component of the signal exceeds ±200 volts, the input range of the 6400 can be extended with Tektronix or similar type matched probes. (Tektronix types P6006, P6007, P6013A, P6049A or P6060, or equivalent).

The probe should match an input resistance of 1 megohm and should be adjustable to match an input capacitance up to 50 pf. The broadbanding screw should be adjusted for 0° (or 360°) reading with a signal directly on one of the phasemeter inputs and the probe (on the other phase meter input) connected to the same signal. Reverse the procedure for a probe on the other phase meter input. For optimum accuracy, the probe(s) should be adjusted at each frequency used before making phase measurements. For less stringent accuracy requirements, the probe(s) need not be adjusted carefully.

If a 10 Megohm probe (or 10 Megohm source impedance) is used on one channel only, below 200 Hz, or a 1 Megohm source impedance below 20 Hz on one channel only, an appreciable error is introduced, because of the phasemeter input coupling capacitors. (10 Megohms will produce approximately 0.8° at 10 Hz). This error can be cancelled by adding an equivalent source impedance in series with the input to the other channel at these low frequencies. (If left in at higher frequencies, it must be accurately broadbanded with a shunt capacitance).

SECTION 3

INCOMING INSPECTION AND CHECKOUT

3.1 INTRODUCTION

The following procedure is used to verify that the phasemeter is operating within specifications, both for incoming inspection and for routine servicing. Tests should be made with all covers in place, and the procedure given below should be followed in sequence.

SPECIAL NOTE

As an alternate to the following procedure, a Primary Phase Angle Standard such as the Dytronics Model 311/RT-1/717S may be used for accuracy measurements between 30 Hz and 10 KHz. A second alternative is the use of a Computing Counter System such as the Hewlett Packard Model 5360A when used with a suitable phase shifting circuit).

3.2 EQUIPMENT REQUIRED

(a) 10 Hz to 100 KHz low distortion* oscillator, with output adjustable from 0.1 volts RMS to 10 volts RMS, Krohn-Hite Model 4000A or equivalent.

(b) 10 Hz to 10 MHz sine wave oscillator, with two outputs, 180° apart, and output voltage adjustable from zero to 1.5 volts RMS, Hewlett Packard Model 654A or equivalent.

(c) Variable phase generator, capable of providing two sine wave and/or square wave outputs, with adjustable phase angle from 0° to 360° Hewlett Packard Model 203A or equivalent.

(d) 10 Hz to 5 MHz square wave signal source, with two outputs, not in phase, and output voltage at least 1 volt peak to peak. (If a signal source with two outputs is not available, a single source may be used with a suitable balanced transformer such as the North Hills Electronics Model 50-201RA, to produce two outputs approximately 180° apart.)

(e) 50 ohm terminators, (2 required), Tektronix type 011-0055-00 or equal. (For use with above transformer only).

(f) Calibrated DPM, zero to -3.6 volts DC, with 0.1 millivolt resolution, Newport Model 2000AS or equal.

(g) Matched set of coaxial cables (BNC) for connections to inputs. (Same length and impedance).

---

* Less than 0.01% from 10 Hz to 20 KHz, rising to 0.1% at 100 KHz.

3.3 PROCEDURE

After allowing the instrument to warm up for at least 30 minutes, set the controls to the following positions:

WAVEFORM	∿
RMS VOLTS RANGE (input A)	0.1-1.2
RMS VOLTS RANGE (input B)	0.1-1.2
READ/HOLD	READ
GROUND SWITCH	CHASSIS

NOTE:

The 5 1/2 digit DPM, connected to the ANALOG output, will provide additional resolution of 0.01°.

3.3.1 Meter Calibration

Press the 0° CAL button. Adjust the screwdriver control on the front panel until the meter reads 000.0°. Press the 360° CAL button. Adjust the screwdriver control on the front panel until the meter reads 360.0°.

3.3.2 100 Hz Sine Wave Check

Connect the output of the low distortion oscillator to both inputs of the phasemeter, using the set of matched cables. Set the oscillator frequency to 100 Hz, output amplitude to 0.1 volts RMS. Depress the 0° CAL button momentarily, then release; meter should read 000.0° ±0.1° ±1 digit. Depress the 360° CAL button, then release; meter should read 360.0° ±0.1° ±1 digit. Repeat procedure at 10 Hz, 1 KHz and 10 KHz.

3.3.3 100 KHz Sine Wave Check

Repeat procedure of 3.3.2 at 100 KHz; meter tolerance is ±0.7°.

3.3.4 High Frequency Sine Wave Check

Connect the outputs of the 10 MHz oscillator to the phasemeter inputs, using the matched cables. Set the oscillator frequency to 200 KHz and both output voltages to 0.1 volts RMS. Observe the phase reading.

Reverse the two inputs. Observe the phase reading. The Total* of both readings should equal 360.0° ±2.8° at 200 KHz. Repeat this procedure at 500 KHz, 1 MHz, 2 MHz and 5 MHz. Tolerance of the total reading is ±7° at 500 KHz, ±14° at 1 MHz, ±28° at 2 MHz and ±70° at 5 MHz. Disconnect the oscillator.

3.3.5 100 Hz Square Wave Check

Set the phasemeter WAVEFORM switch to ⊓⊔. Connect the outputs of the square wave signal source to the phasemeter inputs. (If a signal source with two outputs is not available, proceed as follows: Connect a single square wave source to the input of a suitable balancing transformer, as described in 3.2.c. The output impedance (Z) of the signal source should approximately equal the input Z of the transformer. Some transformers require a load on their outputs equal to their output Z. Check manufacturer's specifications). Set the signal source output

* If both readings are in error by E degrees, the total will be off by (2xE) degrees. Therefore the tolerance of the total is twice the specified accuracy. (See Section 1.2)

voltage for 1 volt peak to peak at the phasemeter inputs. Observe the phase reading. Reverse the inputs and observe the reading. The Total* of both readings should equal 360° ±0.1°. Repeat this procedure at 10 Hz, 1 KHz and 5 KHz. Total of the two readings should be 360° ±0.1°.

3.3.6 20 KHz Square Wave Check

Repeat the procedure of 3.3.5 at 20 KHz; total of the two readings should be 360° ±0.2°.

3.3.7 High Frequency Square Wave Check

Repeat the procedure of 3.3.5 at 200 KHz, 500 KHz, 1 MHz, 2 MHz, and 5 MHz. Tolerance of the total reading from 360° should be ±2.8° at 200 KHz, ±7° at 500 KHz, ±14° at 1 MHz, ±28° at 2 MHz and ±70° at 5 MHz. Disconnect square wave source (and transformer if applicable).

3.3.8 Analog Output Check

Set the phasemeter WAVEFORM switch to ∿ . Connect the sine wave outputs of the variable phase generator to the phasemeter inputs. Set the generator frequency to 1 KHz, output voltage to 1 volt RMS. Using the 5 1/2 digit DPM, check to see that the analog output is approximately -10 mv/degree for any phase angle between 0° and 360°.

3.3.9 Read/Hold Control Check

Set the output angle of the variable phase generator to some angle between 0° and 360°. Press the front panel HOLD button. Remove the phasemeter inputs. The last meter reading should remain stored until the READ button is pressed.

NOTE

The analog output voltage will still vary with a change in the input phase angle, even though the meter display is in the HOLD mode.

* If both readings are in error by E degrees, the total will be off by (2xE) degrees. Therefore the tolerance of the total is twice the specified accuracy. (See Section 1.2)

SECTION 4
CIRCUIT DESCRIPTION

4.1 SYSTEM OPERATION

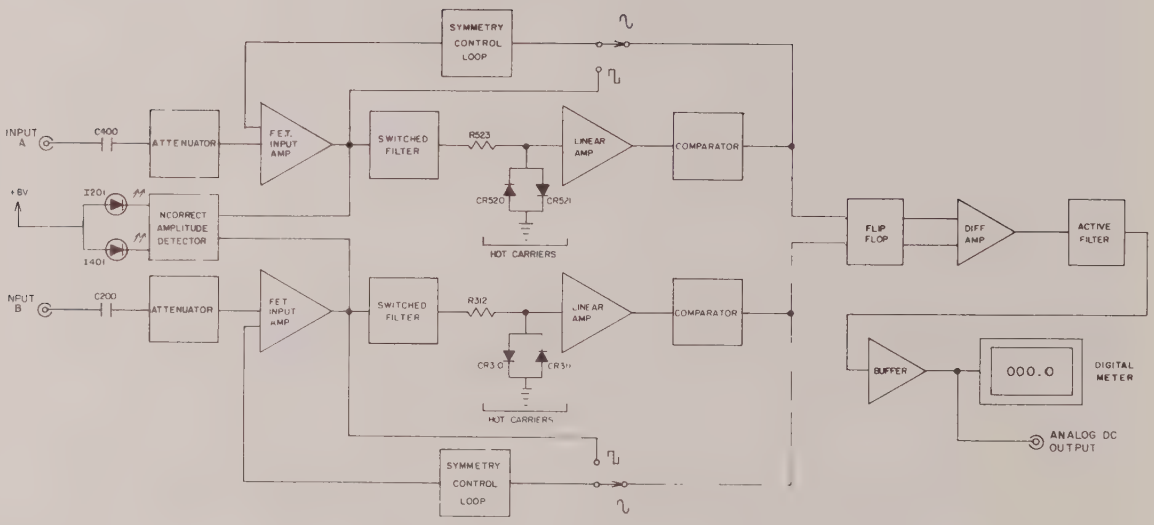


Figure 5. Simplified Block Diagram

A simplified block diagram of the phasemeter circuit is shown in Figure 5. A reference signal is applied to the A input and the signal to be measured is applied to the B input. Each input signal goes through a coupling capacitor, an attenuator, a high impedance (FET) amplifier for isolation and a switched filter that reduces any high frequency signals or noise. Each signal is then fed to a high speed comparator. The comparator detects the point where the input signal crosses the zero axis, and produces a square wave. The output of each comparator is then used to trigger a bi-stable flip flop. The output of the flip flop is a square wave, with a duty cycle that is proportional to the time between the two trigger inputs. The DC average of the accurately clamped flip-flop output is displayed by a digital meter, and corresponds to the phase angle, in degrees, between the two input signals.

4.2 ATTENUATOR AND FET INPUT AMPLIFIER (see figure 6)

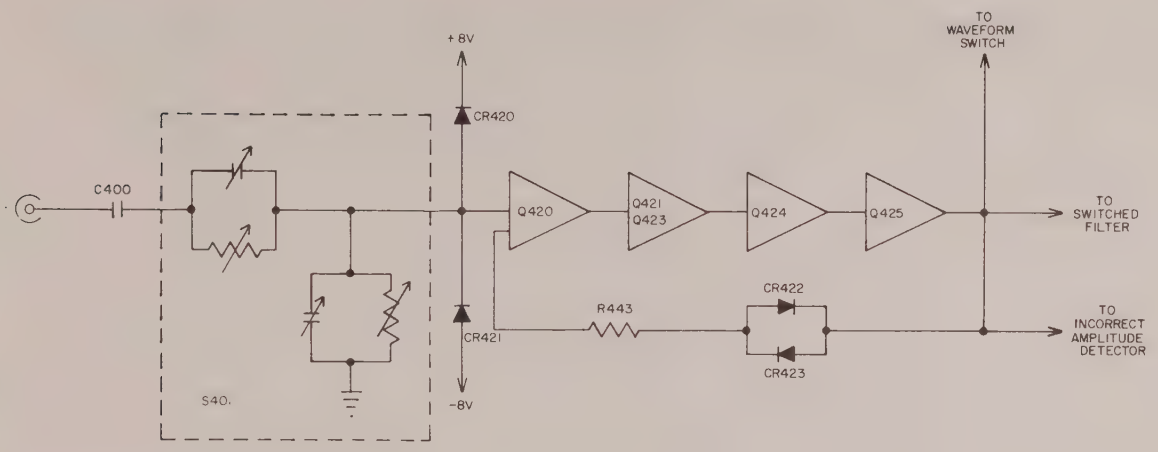


Figure 6. Attenuator and Fet Input Amplifier

(NOTE: since both channels are similar up to their comparator outputs, we shall limit part of the circuit description to channel A.)

The input signal first goes through an AC coupling capacitor, C400, that is matched with C200 for equal low frequency phase shift. The signal is then fed to an attenuator that provides a constant input impedance on all three ranges. Capacitors C401 through C411 are used for broadbanding and to keep the impedance the same on all three ranges at high frequencies. Diodes CR420 and CR421 on the attenuator output prevent damage of the FET amplifier by excessive input signal levels.

The FET amplifier is a high impedance non-inverting amplifier with gain, and consists of an input stage Q420, a balanced differential stage Q421 and Q423, a driver stage Q424, and an emitter follower Q425. The amplifier provides both isolation and gain between the attenuator and the switched filter (section 4.4.) A degenerative path from the amplifier output through CR422, CR423 and R443 limits the amplifier gain and output swing.

4.3 INCORRECT AMPLITUDE DETECTOR (see figure 7)

The incorrect amplitude detector monitors the output of the Fet amplifier. When the input signal voltage falls within the attenuator voltage range selected, the positive DC voltage developed on C464 opens diodes CR 464 and CR465, so that the current in R475 turns Q461 on, turning off Q460, and turning off the LED Set Range Indicator. When the input signal exceeds the upper limit of the attenuator range, the negative DC voltage developed across C463 is sufficient to turn on CR466, turning off Q461 and turning on the LED. When the input signal falls below the selected range Q461 is shut off by the current from the -8v supply through R478, CR464 and CR465. Diode CR465 is in series with CR464 for temperature compensation.

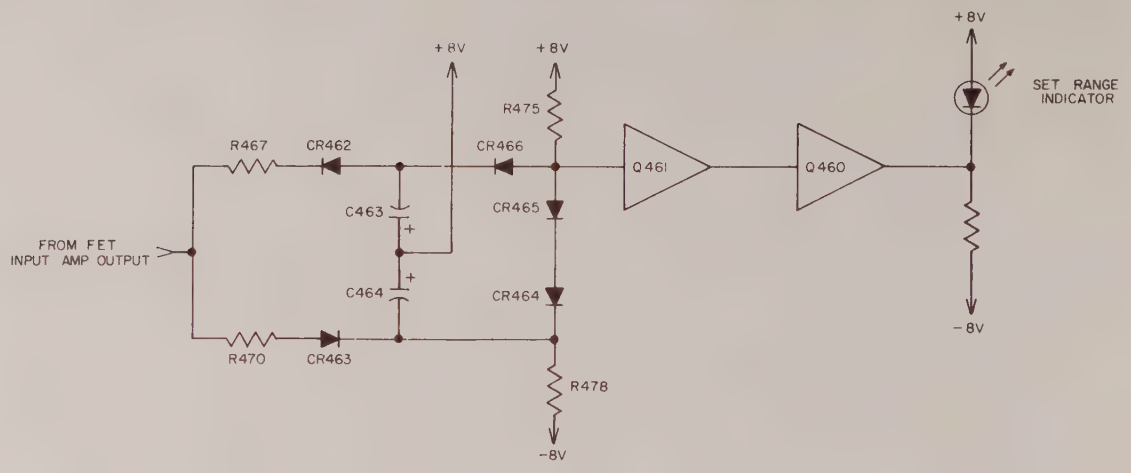


Figure 7. Incorrect Amplitude Detector

4.4 SWITCHED FILTER AND HOT CARRIER LIMITER (see figure 8)

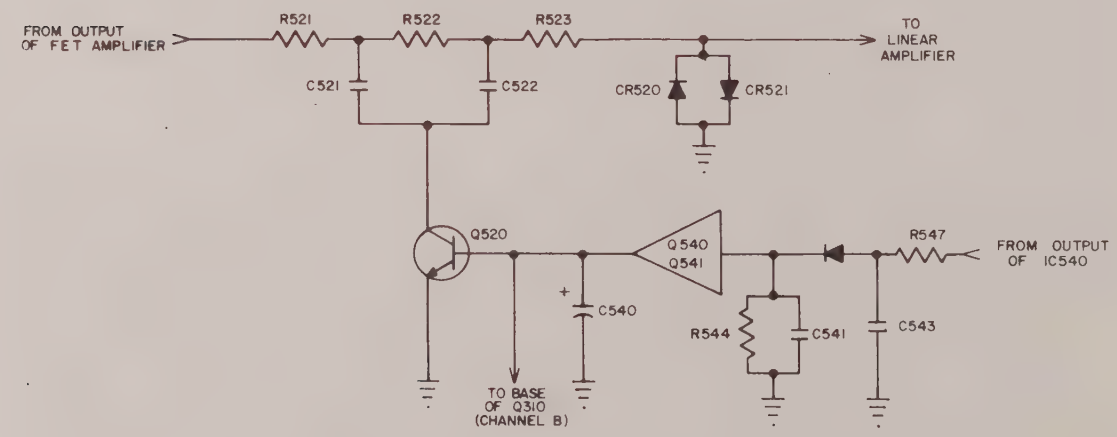


Figure 8. Switched Filter and Hot Carrier Limiter

The switched filter is a low pass filter that is used to reduce excessive high frequency noise at input frequencies below 200 Hz. The control signal is taken from the output of IC540. At low frequencies, the control signal charges C541, turning on Q541 and Q540. This drives the base of Q520 plus, providing a path to ground for C521 and C522.

At frequencies above 200 Hz, the control signal is removed by a bypass capacitor C543, discharging C541, and turning off Q541 and Q540. This drives the base of Q520 negative and opens the path to ground.

The hot carrier limiter consists of two diodes CR520 and CR521. These diodes clamp the input signal at a level of approximately + 0. 3 volts and - 0. 3 volts.

4.5 LINEAR AMPLIFIER (see figure 9)

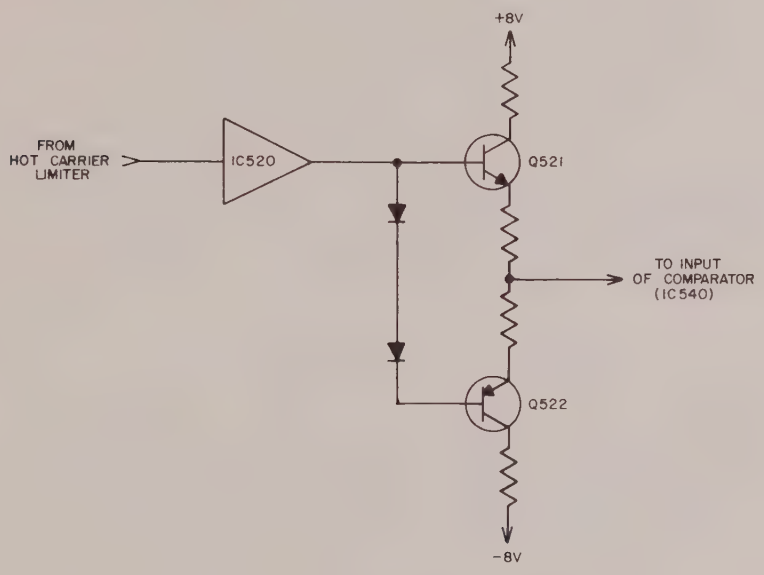


Figure 9. Linear Amplifier

The linear amplifier is an inverting amplifier with gain and consists of an integrated circuit IC520 and a push-pull emitter follower Q521 and Q522. The amplifier serves two purposes: (1) although the hot carrier limiter clamps its input signal at 0. 3 volts, the slope of the clamped signal will vary with the amplitude of the input signal, which in turn will affect the point where the comparator is triggered. The linear amplifier provides sufficient gain so that the difference in the slope is negligible; (2) since the output of the limiter is not sufficient to drive the low impedance of the comparator, the linear amplifier provides the current needed.

4.6 COMPARATOR (see figure 10)

The comparator consisting of IC540 converts the output of the linear amplifier to a fast square wave that is clamped at + 10 volts by CR545. The negative excursion of each comparator is capacitively coupled to the flip flop.

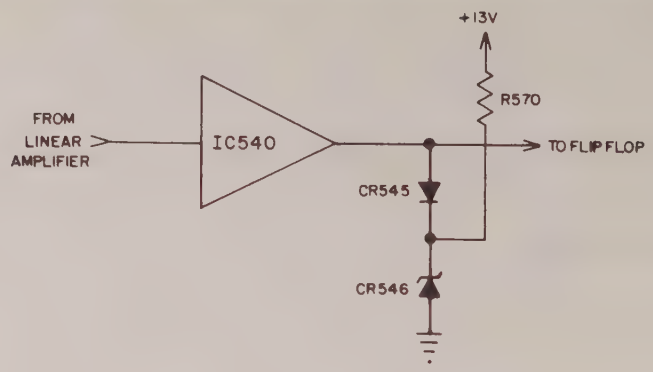


Figure 10. Comparator

4.7 SYMMETRY CORRECTION LOOP (see figure 11)

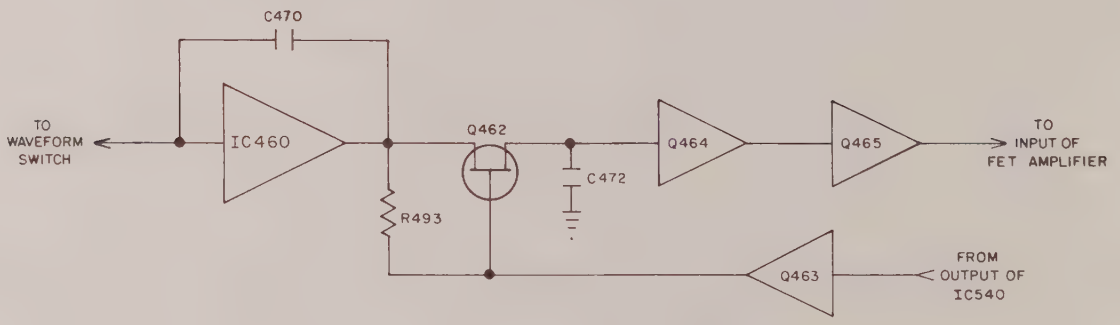


Figure 11. Symmetry Correction Loop

The symmetry correction loop is switched in when the Waveform switch is set to the ∿ mode, and consists of an integrator IC460 and C470, a gated filter Q462 and Q463 and buffers Q464 and Q465. The purpose of this loop is to compensate for phase errors caused by a shift in the DC level of the input signal, which shifts the zero crossover point. The symmetry loop averages the output of the comparator signal from Q466 and Q467 and the resultant DC voltage is fed back to the complementary input of the FET amplifier. If there is no shift in the DC level of the input signal, the signal from Q466 and Q467 will be symmetrical about zero volts, and the DC average will be zero. If a level shift occurs, the square wave signal from Q466 and Q467 will no longer by symmetrical about zero volts, and the average DC voltage from Q466 and Q467 will be fed back to the FET amplifier input and cancel the error.

4.8 FLIP FLOP (see figure 12)

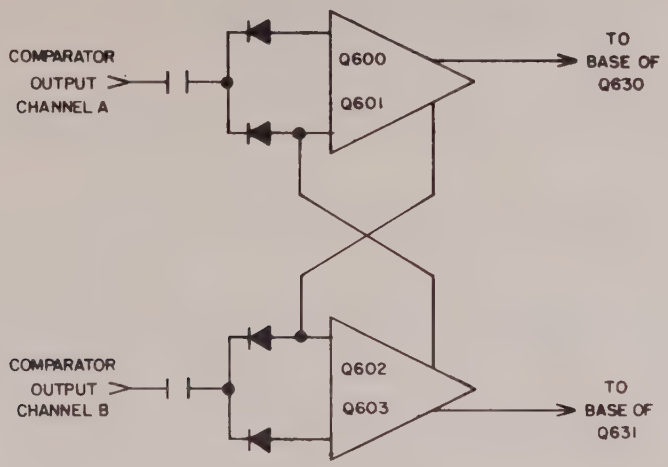


Figure 12. Flip Flop

The Flip Flop consisting of Q600, Q601, Q602 and Q603 operates in a bi-stable non-saturating mode, and is triggered on the negative excursion of each comparator output. The outputs are taken from the collectors of Q601 and Q602.

4.9 DIFFERENTIAL AMPLIFIER AND METER NETWORK (see figure 13)

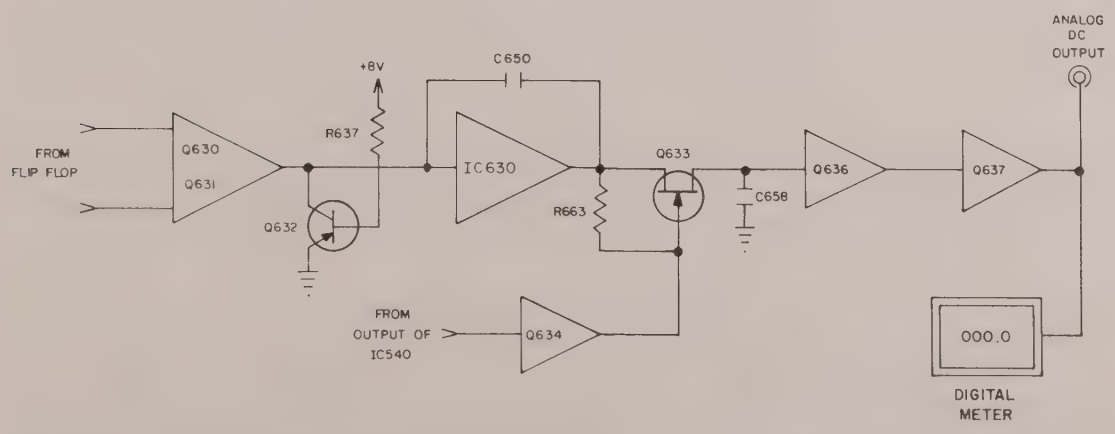


Figure 13. Differential Amplifier and Meter Network

The push-pull output of the flip flop is fed to a differential amplifier Q630 and Q631, which cancels any drift and increases the amplitude of the flip flop output. The base to emitter junction of Q632 functions as a zener, and the base to collector junction clamps the output of the Differential Amplifier at approximately + 6 volts.

The output of the Differential Amplifier is converted to a DC voltage by an active filter, IC 630 and a gated filter Q633 and Q634, providing additional smoothing of the active filter output.

A buffer stage, Q636 and Q637 provides isolation between the gated filter and the digital meter.

The digital meter displays the resultant DC voltage, which corresponds to the phase angle in degrees, between the two input signals.

4.10 POWER SUPPLIES (see figure 14)

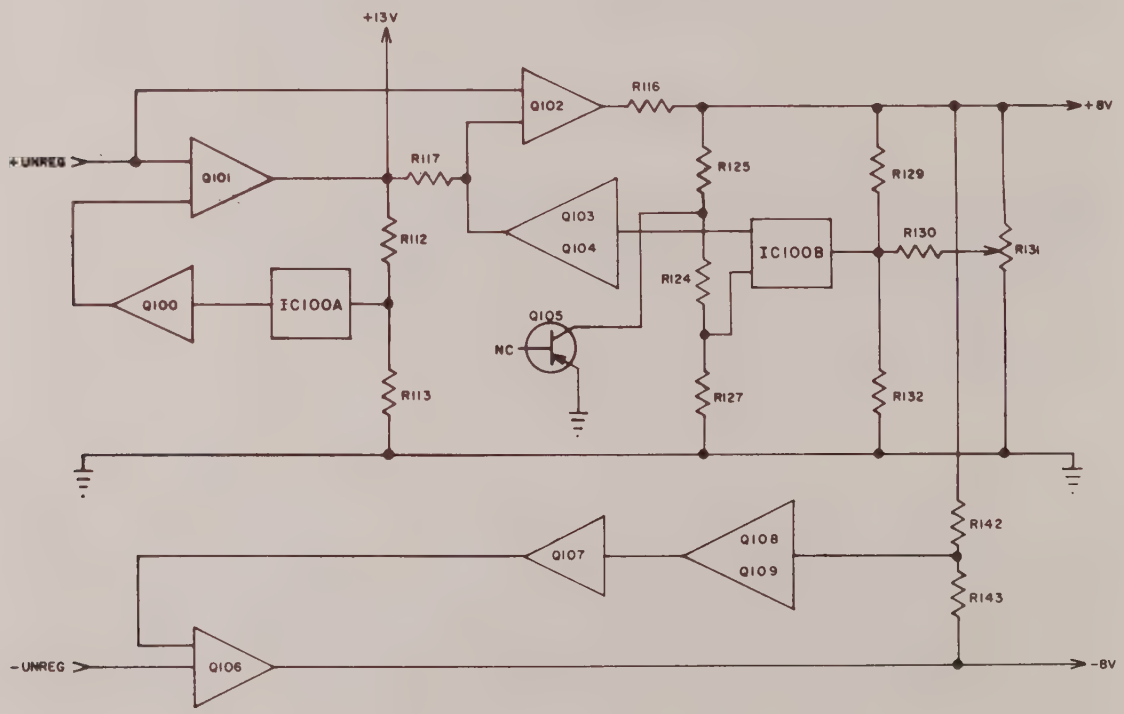


Figure 14. Power Supplies

There are three supply voltages used in the Phasemeter. The ±8 volt supply is used to power the IC' s, and wherever a large signal swing is not needed. The + 13 volt supply is used to provide the additional voltage swing needed on the outputs of the comparator and differential amplifier. Q105 is used as a zener reference for the +8 volt master supply. IC100 is used for improved temperature compensation.

SECTION 5
MAINTENANCE

5.1 INTRODUCTION

If the Phasemeter does not appear to be working properly, the following procedure may facilitate locating the source of trouble. First, check to see if all controls are properly set, and all external connections have been made. Next, make a visual inspection of the unit to locate any broken wires or burnt or broken components. If a visual inspection does not locate the source of trouble, the trouble-shooting procedure given in this section should help to localize the problem. Before attempting any detailed troubleshooting however, reference should be made to Section 4, Circuit Description.

5.2 TEST EQUIPMENT REQUIRED

(a) 10 Hz to 100 kHz low distortion* oscillator, with two outputs 180° apart, adjustable from 0.1 volts RMS to 10 volts RMS.

(b) Oscilloscope, with 1 mv/cm sensitivity and bandwidth of at least 45 MHz, Tektronix type 7403N or equal, with 7B50 Time Base and 7A13 Differential Comparator Amplifier.

(c) Digital voltmeter, zero to 15 volts DC, with 1 mv resolution.

(d) Matched set of coaxial cables (BNC) for connections to inputs. (Same length and impedance).

5.3 POWER SUPPLY

If the phase meter does not seem to be working properly, the power supply circuit should be checked first. The three regulated outputs should measure + 8V ±0.2V, - 8V ± 0.2V, and + 13V ±0.3V. Normal 60 Hz ripple should be less than 2 mv peak to peak. If the preceding three voltages appear to be correct, go to Section 5.4.

The regulated voltages are provided with current limiting circuits that will shut down the supply when excessive current is being drawn from it. Because of this, an apparent power supply malfunction may be the result of an overload in the phase meter circuits. This may be determined by measuring the voltage drop across R104, R116 and R134. These voltages should be no greater than 0.7V. If the voltage across R104, R116, or R134 is considerably greater than 0.7V, measure the voltage across the three power supply PC busses which feed the left channel, the right channel and the rear card circuits. A drop of over 10 millivolts on any of these will indicate that the overload is in that section.

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* Less than 0.01% from 10 Hz to 20 kHz, rising to 0.1% at 100 kHz.

Check the unregulated voltages on the + end of C103 and the - end of C104. If these voltages are correct and if there is no indication of overload, but the +8V regulated output is not correct, check the +8V supply first, because it is the reference for the other supplies. If the +13V (as well as the +8V) is low, connect a 4.7K resistor from the collector of Q103 to the + end of C103. If this corrects the +8V, but not the +13V, the trouble is in the +13V supply.

Normal voltages for various points are given on the schematic diagram in the appendix. A good way to find the source of trouble in any of the three supplies is to trace the error signal developed. For example, if the -8V supply were to become less negative than normal, the base of Q109 would tend to become more positive, allowing less current to flow through it and R140, making both the collector of Q109 and the base of Q107 more negative. This would allow more current to flow through Q107 and make its collector more positive, thus turning on the series transistor Q106 and restoring the -8V supply to its normal level.

NOTE: Most of the circuitry discussed in the following sections is of high impedance making it necessary to use high impedance, low capacitance equipment when making AC or DC measurements.

5.4 SIGNAL TRACING ANALYSIS

If the power supply seems to be functioning properly then the following procedure should localize the malfunction. Set both attenuator switches to the 0.1V-1.2V position. Apply two 1 kHz, 0.1V rms sine waves, 180° apart, to the inputs of the phasemeter. Set the MODE switch to the $\sim$ position. The schematic shows various test points with their correct signal levels. The test points basically trace the signal through the entire system. A quick look at either the Block Diagram (Figure 5, Section 4) or the detailed schematic (appendix) will show that before the two input signals reach the flip-flop, they are processed independently by identical circuitry. Therefore the notation Q222 (Q423) implies that Q222 and Q423 have identical functions in their respective channels.

5.5 FET AMPLIFIER

If test point TP1(6) appears incorrect check Q220 (Q420), CR220 (CR420) and CR221(CR421). If test point TP1 (6) is normal but test point 2(7) is in error first check the output from the symmetry correction loop on TP11 (TP12). If this value is greater than 0.35 volts DC, switch the sine-square switch to square wave. If the output of the symmetry loop is then less than ±0.35 volts DC, the trouble is probably in the limiter (section 5.10), the Linear Amplifier (Section 5.6) or the Comparator (Section 5.7). If there is still more than ±0.35 volts DC, the malfunction is likely to be in the symmetry loop or its associated gated filter or buffer.

If the preceding voltage check shows no malfunction in these circuits, then the malfunction is somewhere between Q221 (Q421) and Q225 (Q425). The signal error can be traced back from test point 2 in the direction of Q221 until the faulty component(s) is (are) located.

5.6 LINEAR AMPLIFIER

If the DC voltage on TP3 (8) is incorrect tie pin 5 to pin 10 of IC310 (IC520). Pin 5 should be zero volts, and TP3 (8) should be approximately -0.6V. If TP3(8) is not -0.6V, check the two diode drop from pin 5 of IC310 (IC520) to the base of Q312 (Q522). This should be around 1.2V. If this checks out and pin 5 of IC310 (IC520) is at 0.0V then the malfunction is associated with either Q311 (Q521) or

Q312 (Q522). If pin 5 of IC310 (IC520) is not zero, check to see that the plus and minus supplies reach their respective pins on IC310 (IC520). If they do, then IC310 (IC520) is the source of the problem. If TP3(8) does go to -0.6V check the negative feedback loop from TP3 to pin 10 to see if there is an open circuit. If not, the malfunction is probably between TP2 and the inputs of IC310 (IC520). The problem can be further localized by tracing the signal from TP2 towards IC310 (IC520).

5.7 COMPARATOR

First check pin 3 of IC330 (IC540) to see that the signal, normally around 8V p-p, reaches it from TP3(8). If not, check the components between the two above mentioned points. There is a small amount of regenerative feedback from the output (pin 7 of IC330 (IC540)) to the + input (pin 2), but the DC signal level at pin 2 should not be much greater than 100 mv p-p. If it is, check the feedback circuitry. If both inputs appear normal but the output, pin 7, refuses to change state (OV or +10V) in response to pin 3, the problem is probably with IC330 (IC540) but it could also be accounted for if CR331 (CR546) has gone bad or CR330 (CR545) is shorted.

5.8 FLIP FLOP AND DIFFERENTIAL AMPLIFIER

Depress the 0° CAL button and then the 360° CAL button while monitoring the DC level at TP 4. The voltages should be approximately OV and 6.6V for 0° and 360° respectively. Correct values here indicate that the source of the problem is after the Differential Amplifier. If these voltages are incorrect, monitor the collector of Q630 in the 0° and 360° cal modes. Correct levels here are -0.5V and 8.5V for 0° and 360° respectively. Repeat for Q631. Correct levels here are 8.5V and -0.5V for 0° and 360° respectively. Correct levels here indicate the malfunction is between the two above mentioned collectors and TP4. If these voltages are incorrect check the DC levels at the collector of Q602 in the 0° and 360° cal. modes. Correct values are 9.5V and 8V respectively. Using this same procedure check the 0° and 360° CAL levels at the collector of Q601. Correct levels are 8V and 9.5V respectively. Proper levels at the collectors of Q601 and Q602 indicate that Q630 or Q631 or their associated circuitry is the source of the malfunction. Incorrect voltages at the collectors of Q601 and Q602 indicate a malfunction in the flip-flop or the calibration switch. Check the switch for faulty contacts. If the switch seems in order, then the malfunction is most likely associated with the four transistors that make up the flip-flop. Measure the emitter to base voltage drop in each of the four transistors while in the 360° and 0° CAL modes. In at least one of the two CAL positions the transistor in question should show a minimum voltage drop of -0.6V. (On 0° CAL, Q600 and Q602 are "on" and Q601 and Q603 are biased off. On 360° CAL, Q600 and Q602 are biased off and Q601 and Q603 are "on").

5.9 ACTIVE FILTER LOOP, GATED FILTER AND BUFFER

For this section it will be necessary to short pin 5 to pin 10 of IC630. This can be most easily done by putting a jumper wire across C650. The DC level at pin 5 should now be 0V plus a small offset (a max. of ±15 mv). If not, check the DC level of pin 9 of IC630. If this does not produce results IC630 is probably the source of trouble. If pin 5 showed only the acceptable offset check the DC level at the drain of Q633. It should have essentially the same value as pin 5 of IC630. Monitor the signal level at the collector of Q634. There should be a base line DC level of -7V with pulses to +7V. (DC average

approx. -4.6V). If not check Q634 and CR637. Monitor the signal level at the base of Q634. There should be a base line DC level of -7V with pulses to -12V. If not check CR548, C547 and R574. Check the DC level at the source of Q636 (R679). This should be ±0.3V, ±0.2V. If not check the voltage drop across CR640. If it is normal (between 0.5V and 0.8V), Q636 is probably bad. If the drop across CR640 is not within these normal limits set, check the diode itself. Monitor the DC level at the base of Q637. It should be around -0.65V. If not check R679. Check the DC level at the emitter of Q637. This voltage should be around -1.3V. If not, Q637 is probably the source of trouble.

5.10 LIMITER

If the limiter output at the junction of R294 (R505) and R295 (R506) is not swinging sufficiently positive, the trouble may be Q266 (Q466). If this output is not negative enough, the trouble may be Q267 (Q467) or the driver Q268 (Q468) or the associated circuitry.

5.11 SYMMETRY CORRECTION, GATED FILTER, BUFFER

In this section it will be necessary to short pin 5 to pin 10 of IC260 (IC460). This can be most easily done by placing a jumper wire across C270 (C470). The DC level at pin 5 should now be OV except for a small offset (a max. of ±15 mv). If not check R283 (R487). If this does not produce results IC260 (IC460) is probably the source of trouble. If pin 5 showed only the acceptable offset check the DC level at the drain of Q262 (Q462). It should have essentially the same value as pin 5 of IC260 (IC460). Monitor the signal level at the base of Q263 (Q463) to see that the comparator output reaches it. The signal should be around -7 VDC base line with pulses to -12V. Check the signal level at the gate of Q262 (Q462). This point should be around -8V DC base line with pulses to +2.5 V. If not, check Q262 (Q462) and Q263 (Q463). Monitor the DC level at the source of Q264(Q464). The correct value here is about +2 VDC. If this disagrees with the measured value check R287 (R497), R289(R498) and Q264 (Q464). In narrowing down the malfunction to the faulty component, it will be helpful to note that the base of Q265 (Q465) should be around + 0.5 VDC. Check the DC level at TP11 (TP12) [emitter of Q265 (Q465)] for a value of 0 ±0.6V. If the measured value is very different, Q265 (Q465) is probably defective.

5.12 SET RANGE INDICATORS

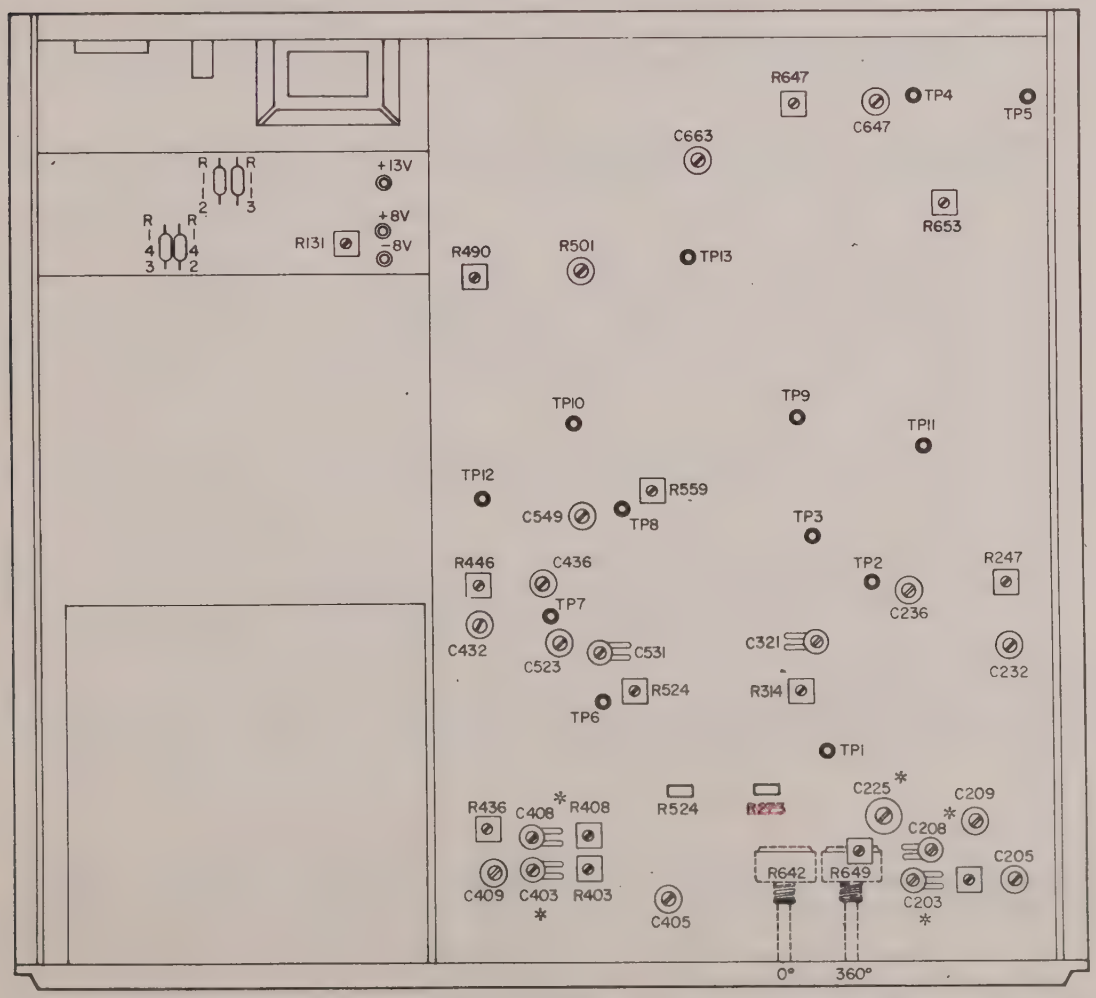
If the LED Set Range Indicators are not working properly, proceed as follows:

Apply a .08 volt RMS, 100 Hz sine wave to both inputs of the phasemeter. Set the VOLTS RANGE switches to 0.1-1.2, WAVEFORM switch to ∿. Adjust R273(R477) until the LED flickers or just goes out. If R273(R477) cannot be adjusted properly then Q260(Q460) or Q261(Q461) or their associated components are defective. (Refer to Section 4.3.)

SECTION 6
CALIBRATION

6.1 INTRODUCTION

The following procedure is provided for periodic calibration and adjustment of the phasemeter in the field, and adherence to this procedure should restore the phasemeter to its performance specifications. All tests should be made with covers in place. If the phasemeter cannot be calibrated by the procedure given, refer to Maintenance, Section 5, or consult our factory service department. The location of test points and adjustable components are shown in Figure 15.



*(These trims may be adjusted through slots provided in the top cover of the instrument.)

Figure 15. Test Points and Adjustable Components

SPECIAL NOTE

As an alternate to the following procedure, a Primary Phase Angle Standard such as the Dytronics Model 311/RT-1/717S may be used for accuracy measurements between 30 Hz and 10 KHz. A second alternative is the use of a Computing Counter System such as the Hewlett Packard Model 5360A when used with a suitable phase shifting circuit.

6.2 TEST EQUIPMENT REQUIRED

(a) Oscilloscope, with 1 mv/cm sensitivity and bandwidth of at least 45 MHz, Tektronix type 7403N or equal, with 7B50 Time Base, 7A13 Differential Comparator Amplifier and calibrated X1 probe.

(b) 10 Hz to 100 KHz low distortion* oscillator, with 200 ohm main and quadrature outputs adjustable from 0.1 volts RMS to 10 volts RMS, Krohn-Hite Model 4024A or equivalent.

(c) 10 Hz to 10 MHz sine wave oscillator, with 135 ohm balanced outputs (67.5 ohms each output), adjustable from zero to 1.5 volts RMS, Hewlett Packard Model 654A or equivalent.

(d) 10 Hz to 10 MHz sine/square generator, output adjustable from zero to 10 volts RMS, Krohn-Hite Model 4300 or equivalent.

(e) Digital voltmeter, zero to 15 volts DC, with 1 mv resolution, Fluke Model 8000A or equivalent.

(f) AC differential voltmeter, 10 mv to 10 volts RMS, Fluke Model 931P or equivalent.

(g) Wideband attenuator, 50 ohm input and output impedance, Texscan Model LA-51 or equivalent.

(h) X10 oscilloscope probes (2 required), Tektronix type P6006, P6049A or P6060.

(i) 75 ohm terminator (2 required), Tektronix type 011-0055-00 or equal.

(j) 50 ohm terminator, Tektronix type 011-0049-01 or equal.

(k) Matched set of coaxial cables (BNC) for connections to inputs. (Same length and impedance).

(l) Calibrated 5 1/2 digit DPM, zero to -3.6 volts DC, with 0.1 mv resolution, Newport Model 2000AS or equal.

6.3 TEST PROCEDURE

After allowing the unit to warm up for at least 30 minutes, set the controls to the following positions:

WAVEFORM	∿
RMS VOLTS RANGE (input A)	0.1-1.2

* Less than 0.01% from 10 Hz to 20 KHz, rising to 0.1% at 100 KHz.

RMS VOLTS RANGE (input B)	0.1-1.2
READ/HOLD	READ
GROUND SWITCH	CHASSIS

6.3.1 Power Supplies

Check the voltages at the following test points, and adjust if necessary.

Test Point	Value	Adjustment
TP + 8	+ 8V ± 0.2V	R131
TP + 13	+ 13V ± 0.3V	R112, R113
TP - 8	-8V ± 0.2V	R142, R143

6.3.2 0^{o} and 360^{o} CAL Adjust

Connect the 5 1/2 digit external DPM to the phasemeter analog output. Set the front panel 0^{o} ADJ pot (R642) for 0 ± 0.1 volts DC on its center arm. Adjust R647 for 0 ± 1 mv at TP4. Depress the 0^{o} CAL button. Adjust R642 for a reading of 0.0000V on the external DPM. *

Set the front panel 360^{o} ADJ pot (R649) for the center of its range. Depress the 360^{o} CAL button and adjust R653 for a reading of -3.6000V on the external DPM.

6.3.3 Symmetry Correction Loop Adjust

Connect one of the outputs of the balanced oscillator to channel A; connect the other output to channel B. Set the oscillator frequency to 1 KHz, output to 1V RMS at each phasemeter input. Adjust R247 for 0 ± 0.2 volts DC at TP11. Adjust R446 for 0 ± 0.2 volts DC at TP 12. Disconnect the balanced oscillator.

6.3.4 0^{o} and 360^{o} Calibration (100 Hz)

Depress the phasemeter 0^{o} CAL button. Adjust the 0^{o} ADJ pot for a DPM reading of 0.0000V. Depress the 360^{o} CAL button. Adjust the 360^{o} ADJ pot for a reading of -3.6000V.

Connect the output of the low distortion oscillator to both inputs of the phasemeter, using a matched set of coaxial cables. Set oscillator frequency to 100 Hz, output to 0.1 volts RMS. Depress the 0^{o} CAL button momentarily, then release. DPM should read 0.0000V. If off, adjust R501.

Depress the 360^{o} CAL button momentarily, then release. DPM should read -3.6000V. If off, adjust R490. Recheck 0^{o} CAL and readjust, if necessary. Disconnect the oscillator.

6.3.5 Phase Vs. Amplitude, Input A

Connect the low distortion oscillator and wideband attenuator to the phasemeter as shown in Figure 16. Set the oscillator frequency to 10 KHz, and adjust the main and quadrature outputs for 1 Volt RMS at each phasemeter input. Adjust R524 for a minimum change in DPM reading when switching the wideband attenuator from 0 db to 20 db. Tolerance: ±0.0003V.

*(When making adjustments, refer to the external DPM reading, but monitor both DPM and phasemeter display. If both readings differ by more than 0.5^{o}, both meters should be checked.)

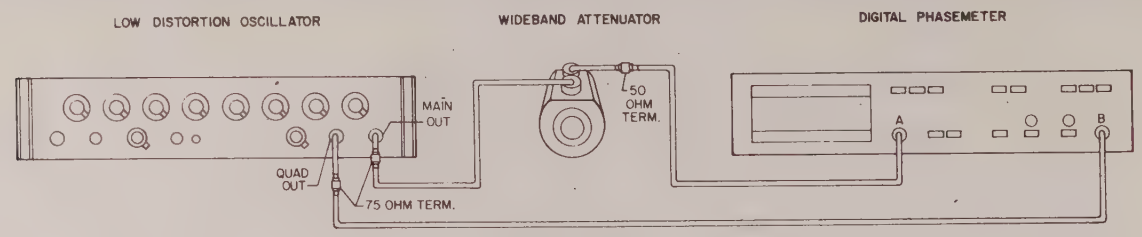


Figure 16. Phase Vs. Amplitude, Input A, Test Set-Up

Set oscillator to 50 KHz. Maintain 1 volt RMS on phasemeter inputs. Adjust C531 for a minimum change in DPM reading when switching the wideband attenuator from 0 db to 20 db. Tolerance: ±0.0003V.

Switch wideband attenuator from 0 db to 10 db. Adjust C436 for a minimum change in DPM reading. Tolerance: ±0.0003V.

6.3.6 Phase Vs. Amplitude, Input B

Connect the low distortion oscillator and wideband attenuator as shown in Figure 17. Set the oscillator frequency to 10 KHz, and adjust the main and quadrature outputs for 1 volt RMS at each phasemeter input. Adjust R314 for a minimum change in DPM reading when switching the wideband attenuator from 0 db to 20 db. Tolerance: ±0.0003V.

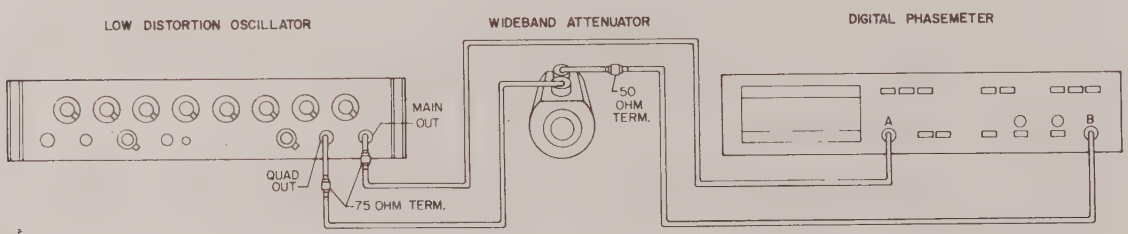


Figure 17. Phase Vs. Amplitude, Input B, Test Set-up

Set oscillator to 50 KHz. Maintain 1 volt RMS on phasemeter inputs. Adjust C321 for minimum change when switching wideband attenuator from 0 db to 20 db. Tolerance: ±0.0003V.

Switch wideband attenuator from 0 db to 10 db. Adjust C236 for a minimum change in DPM reading. Tolerance: ±0.0003V. Remove terminators, attenuator and quadrature output from phasemeter.

6.3.7 Phase Vs. Frequency Adjust

Reset 0° CAL and 360° CAL adjust (if necessary). Connect the main output of the low distortion oscillator to both inputs of the phasemeter, using matched cables. Set oscillator frequency to 100 Hz, output to 0.1 volts RMS. Depress 0° CAL button momentarily, then release. DPM should read 0.0000V. If off, readjust R501.

Set oscillator frequency to 50 KHz. Maintain 0.1 volts RMS on oscillator output. Depress 360° CAL button momentarily, then release. Adjust C225 for a DPM reading of -3.6000V, ± 0.0010V.

Set oscillator frequency to 100 KHz output at 0.1 volts RMS. Depress the 360° CAL button momentarily, then release. Adjust R436 for a reading of -3.6000V, ± 0.0070V. Recheck 50 KHz.

6.3.8 Phase Vs. Attenuator Setting, Input A

Change oscillator frequency to 10 KHz, output to 1 volt RMS. Depress 360° CAL button momentarily, then release. DPM should read -3.6000V. Switch input A attenuator to 1-12V position. Adjust C403 for minimum change when switching from 0.1-1.2V to 1-12V position. Tolerance: ±0.0004V.

Switch input A attenuator to 0.1-1.2V position. Change oscillator frequency to 40 KHz. Depress 360° CAL button momentarily, then release. Switch input A attenuator to 1-12V position. Adjust R403 for minimum change. Tolerance ±0.0004V.

Set both input attenuators to the 1-12V position. Change the oscillator frequency to 10 KHz, output to 10 volts RMS. Depress 360° CAL button momentarily, then release. DPM should read -3.6000V. Switch input A attenuator to 10-120V position. Adjust C408 for minimum change. Tolerance: ±0.0004V.

Switch input A attenuator to 1-12V position. Change oscillator frequency to 40 KHz, output at 10 volts RMS. Depress 360° CAL button momentarily, then release. DPM should read -3.6000V. Switch input A attenuator to 10-120V position. Adjust R408 for minimum change. Tolerance: ±0.0004V.

6.3.9 Phase Vs. Attenuator Setting, Input B

Set both input attenuators to 0.1-1.2V position. Set oscillator frequency to 10 KHz, output to 1 volt RMS. Depress 0° CAL button momentarily, then release. DPM should read 0.0000V. Switch input B attenuator to 1-12V position. Adjust C203 for minimum change. Tolerance: ±0.0004V.

Reset input B attenuator to 0.1-1.2V position. Set oscillator frequency to 40 KHz, output to 1 volt RMS. Depress 0° CAL button momentarily, then release. DPM should read 0.0000V. Switch input B attenuator to 1-12V position. Adjust R203 for minimum change. Tolerance: ±0.0004V.

Set both input attenuators to 1-12V position. Change oscillator frequency to 10 KHz, output to 10 volts RMS. Depress 0° CAL button momentarily, then release. DPM should read 0.0000V. Switch input B attenuator to 10-120V position. Adjust C208 for minimum change. Tolerance: ±0.0004V.

Switch input B attenuator to 1-12V position. Change oscillator frequency to 40 KHz, output to 10 volts RMS. Depress 0° CAL button momentarily, then release. DPM should read 0.0000V. Switch input B attenuator to 10-120V position. Adjust R208 for minimum change. Tolerance: ±0.0004V. Disconnect phasemeter inputs.

6.3.10 Attenuator Impedance Adjust (Inputs A and B)

Connect a square wave generator to the phasemeter inputs, using two (2) x 10 probes as shown in Figure 18. Set input attenuators to 0.1-1.2V, phasemeter waveform switch to ⌐¬. Set the generator frequency to 1 KHz, output to .3V p-p. Connect the oscilloscope, using a calibrated X10 probe to phasemeter TP7. Set the oscilloscope for 10 mv/cm, Cal., AC coupled, horizontal to .2 ms/cm Cal. Adjust the probe connected to input A for a good square wave on the scope. (A slight ringing is normal).

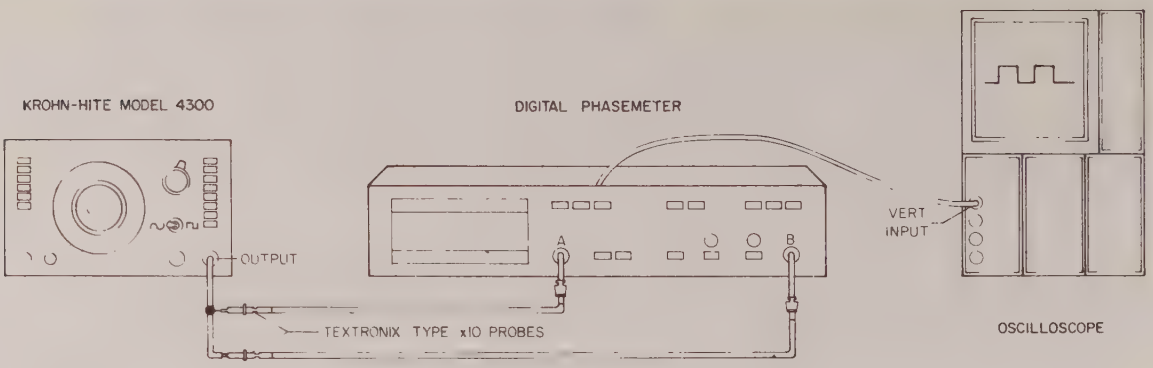


Figure 18. Attenuator Impedance Adjustment Test Set-up

Connect the oscilloscope probe to TP2. Adjust the probe connected to input B for a good square wave on the scope. (A slight ringing is normal).

Switch both input attenuators to 1-12V position. Set generator output to 3V p-p on each phasemeter input. Change the scope vertical to .1 volt/cm, Cal. Connect scope probe to TP7. Adjust C405 for a good square wave. Connect scope probe to TP2. Adjust C205 for a good square wave.

Switch both attenuators to 10-120V position. Set the generator output for 30V p-p. Change the scope vertical to 1 volt/cm Cal. Connect the oscilloscope probe to TP7. Adjust C409 for a good square wave.

Connect the oscilloscope probe to TP2. Adjust C209 for a good square wave. Remove generator, oscilloscope, and X10 probes.

6.3.11 Incorrect Amplitude Indicator Adjust

Connect the main output of the low distortion oscillator to both phasemeter inputs, using matched cables. Set the oscillator frequency to 100 Hz, output amplitude to exactly 0.09 volts RMS. Set both phasemeter input attenuators to 0.1-1.2V positions, waveform switch to ∿. Adjust R477 so that the input A indicator light just goes out. Adjust R273 so that the input B indicator light just goes out.

6.3.12 Phase Vs. Frequency Calibration Check (50 kHz)

Leave the output of the low distortion oscillator connected to both phasemeter inputs. Change the oscillator output to 0.1 volts RMS. Depress the 0° CAL button and readjust the 0° CAL ADJ pot for a DPM reading of 0.0000V. Depress the 360° CAL button and readjust the 360° CAL ADJ pot for a reading of -3.6000V. Depress the 0° CAL button momentarily, then release. Readjust R501 for a DPM reading of 0.0000V. Depress the 360° CAL button momentarily, then release. Readjust R490 for a DPM reading of -3.6000V.

Change oscillator frequency to 50 KHz, output to 0.3 volts RMS. Depress the 360° CAL button momentarily, then release. Readjust C225 for a DPM reading of -3.6000V. Depress the 0° CAL button momentarily, then release. Adjust C647 for a DPM reading of 0.0000V. Recheck -3.6000V at 50 KHz (C225). Disconnect the low distortion oscillator.

6.3.13 Phase Vs. Frequency Adjust (5 MHz)

Connect the outputs of the balanced oscillator to the phasemeter inputs. Set the oscillator frequency to 5 MHz, output to 0.3 volts RMS. Note phasemeter reading. Reverse the two phasemeter inputs. Note DPM reading. The sum of both readings should equal -3.6000V, ± 0.6000V. If off, adjust R559. Change oscillator frequency to 500 KHz, output to 0.3 volts RMS. Note DPM reading. Reverse phasemeter inputs and note DPM reading. The sum of both readings should equal -3.6000V, ± 0.0600V. If off, adjust C523 and/or C549. Disconnect balanced oscillator.

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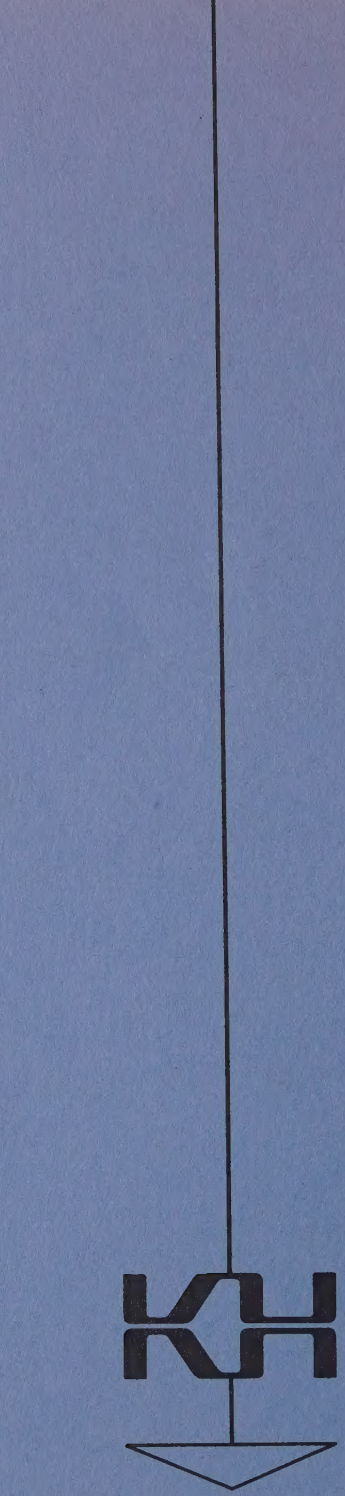

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